#### Topics



- Review of October 2011 NAC Briefing
- ESD Overview / 2013 Budget Highlights
- Status
  - Orion/Multi-Purpose Crew Vehicle
  - Space Launch System
  - Ground Systems Development and Operations
- Flight Test Strategy
- Affordability
- Near-Term Significant Events

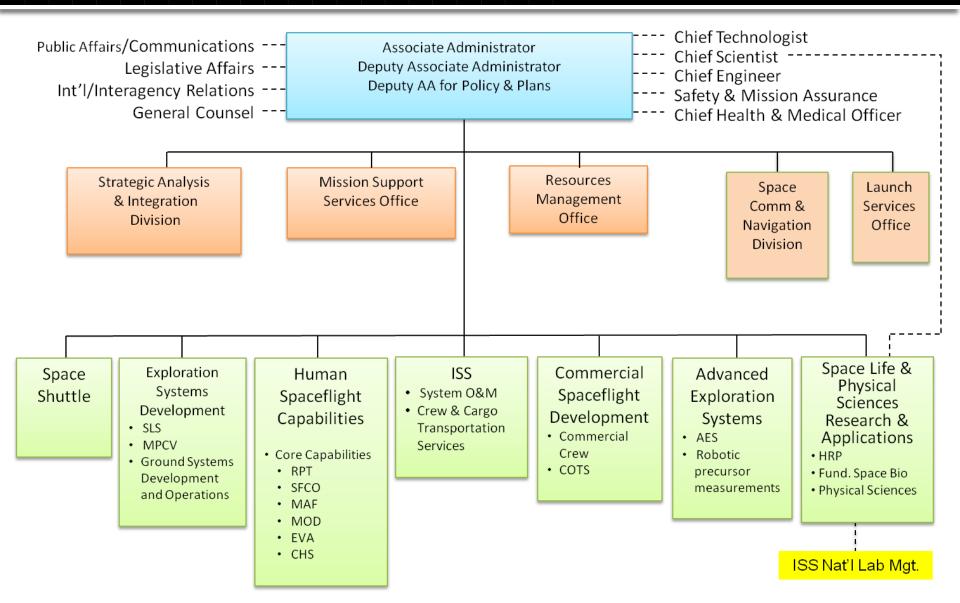
### Review October 2011 NAC



- System Configuration
  - Orion Multi-purpose Crew Vehicle: Announced May 24, 2011
  - Space Launch System: Announced September 14, 2011
- Independent Cost Analysis Findings
- MPCV/SLS report required by Section 309 of the Authorization Act of 2010 delivered to Congress December 23, 2011
- Formulation Authorization Documents for all three programs are signed
- Cross-Program System Requirements Review kick-off on November 2-3, 2011;
   Approved at Agency Program Management Council on February 7, 2012

### **Human Exploration & Operations: Organization**





### **Exploration Systems Development Overview**



These programs will develop the launch and spaceflight vehicles that will provide the initial capability for crewed exploration missions beyond LEO.

- The Space Launch System (SLS) program is developing the heavy lift vehicle that will launch the crew vehicle, other modules, and cargo for these missions
- The Orion Multi-Purpose Crew Vehicle (MPCV) program is developing the vehicle that will carry the crew to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe re-entry from deep space return velocities
- The Ground Systems Development and Operations (GSDO) program is developing the necessary launch site infrastructure to prepare, assemble, test, launch and recover the SLS and Orion MPCV flight systems

## **ESD Integration Approach**Setting the context of ESD and Programs



## ESD is a division within the HEO Mission Directorate that integrates a portfolio of incrementally-developed capabilities

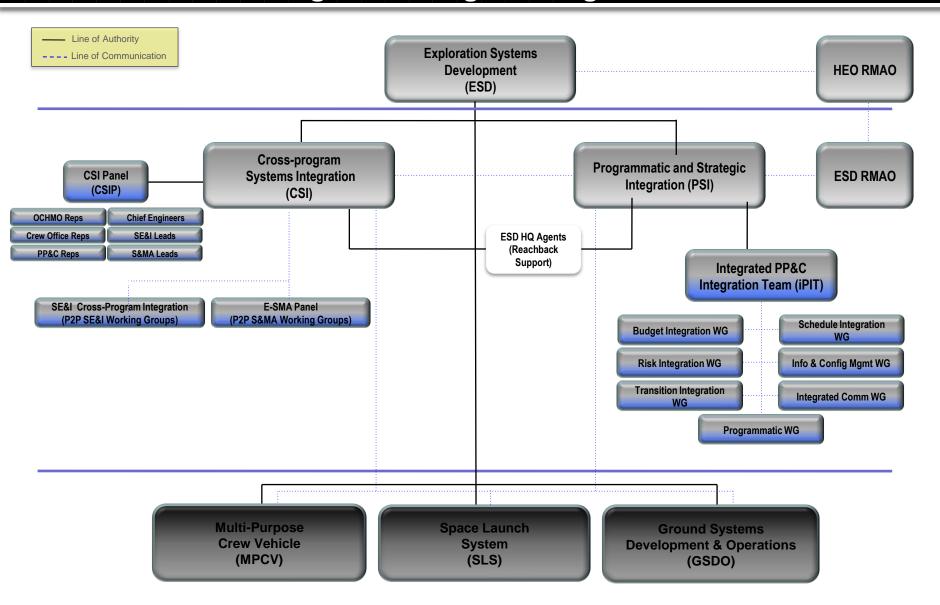
#### ESD Responsibilities

- Lead cross program integration
  - Manage integrated hazards, cross-program interfaces, integrated risks, top level integrated schedule, integrated budget
  - Assure interfaces across programs are properly defined, implemented, and resolved for best overall system solution
  - Ensure cross-program integration issues are being worked in a timely manner, and supported by the Programs
  - Lead integrated system trade studies as needed to address technical / programmatic issues
- Provide insight of programs (MPCV, SLS, and GSDO) to HEOMD AA
- Provide external stakeholder communication
- Enable Programs to focus on developing and delivering the human exploration systems

Programs now perform many program integration functions under the leadership of ESD

## ESD HQ Organization and Interfaces ESD Division and Program-to-Program Integration





#### 2013 Budget Highlights - ESD



#### Outyears are notional

	2013	2014	2015	2016	2017
ESD	2,769	2,913	2,913	2,913	2,913

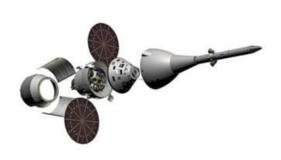
- By September 30, 2013, NASA will finalize cross-program requirements and system definition so that the first test flight of the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) programs are successfully achieved at the end of 2017 in an efficient and cost effective way.
- Provides steady funding for SLS and Orion MPCV, along with associated Exploration Ground Systems (EGS).
- Exploration Systems Development (ESD) related funding is also in the Programmatic CoF (\$143.7 million) which is included in the CECR account.
- Prioritizes work on existing contracts to maintain progress and minimize workforce disruptions.



### 2013 Budget Highlights – ESD (cont.)



- Develops the heavy-lift vehicle (\$1.88B in FY 13, including construction and exploration ground systems) that will be capable of launching the crew vehicle, other modules, and cargo for missions beyond low Earth orbit.
  - SLS selected architecture is an Ares/Shuttle-derived solution
- Corresponding modifications to the Kennedy Space Center launch range will be addressed by Exploration Ground Systems (EGS) program (\$0.4B in FY 2013, including construction).
  - NASA will modify Launch Complex 39 to support 2017 launch



- Develops the Orion Multi-Purpose Crew Vehicle (\$1.0B in FY13, including construction) that will carry crew to orbit, provide emergency abort capability on launch, sustain the crew while in space, and provide safe re-entry from deep space return velocities.
  - NASA designated the beyond-LEO version of Orion ("block 2") as the MPCV selected architecture, and will pace funding so the vehicle will be available in tandem with SLS.
  - Supports Exploration Flight Test 1 (EFT-1) in FY 2014 to reduce crew vehicle program cost and schedule risks.

# Orion MPCV Ground Test Article





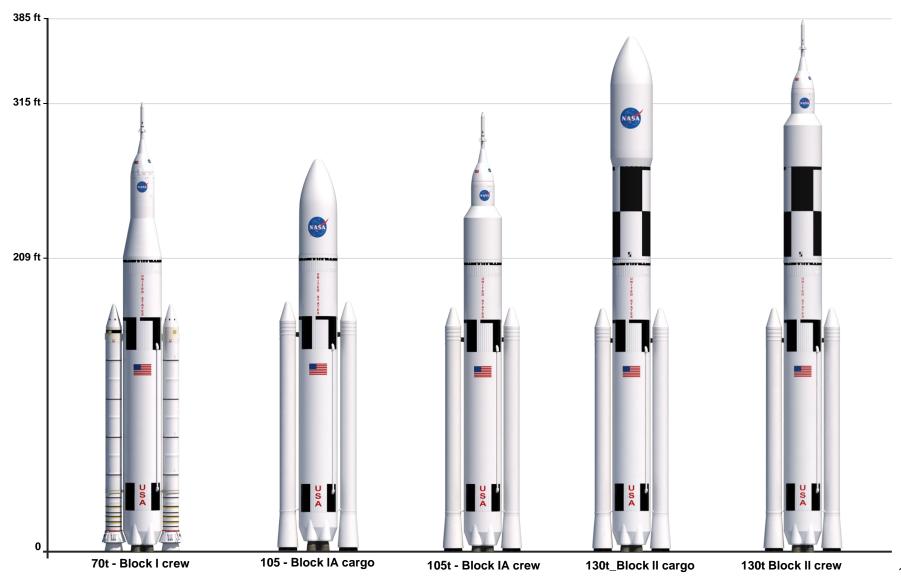
#### **Orion MPCV Status**



- EFT-1 Flight Test Undefinitized Contractual Action (UCA) issued Dec. 21, 2011;
   JOFOC Posted Jan. 5, 2012
- Initiated final CM barrel machining, completed cone and gore panel welding, delivered and assembled backbone
- Completed Drogue Chute Wind Tunnel Nov. 18, 2011
- Phase 1 Water Drop Testing Completed Jan. 6, 2012
- Conducted drop test of the Orion crew vehicle's entry, descent and landing parachutes on Feb. 29, 2012

# **SLS**Evolvable Configurations





## **Exploration Systems Division**Space Launch System (SLS)



- Detailed Synopses Posted on September 28:
  - Core Stage Engines
  - Stages Acquisition
- Detailed Synopses Posted on October 7:
  - Advanced Booster Engineering Demonstration and Risk Reduction
  - Advanced Development Request for Information
- SLS Industry Day at Marshall Space Flight Center on September 29
- SLS Industry Day at Michoud Assembly Facility on November 14
- Pratt & Whitney Rocketdyne Undefinitized Contractual Action (UCA) Released on November 29
- ATK UCA Released on December 16
- Boeing UCA Released on December 21
- SLS Advanced Development Industry & Academia Day at Marshall Space Flight Center on February 14
- Upper Stage Engine (USE) development engine testing:
  - FY12 Q1 4 tests completed, FY12 Q1 ~ 955 seconds of USE hot-fire time, Cumulative 10 tests ~ 1040 seconds of hot-fire test time, Successfully demonstrated full flight USE mission duration



### **Notional GSDO Range**





### Flexible Approach





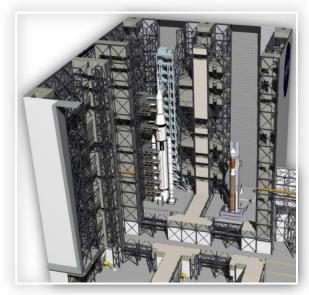
**Horizontal Launch & Landing** 



**Clean Floor Processing** 



**Small Vehicle Launch** 



**Multi-Use Integration (VAB)** 



Flexible Launch Capability



**Heavy Class Launch Capability** 

#### **GSDO Status**



- Mobile Launcher move to Pad B
- Vehicle Assembly Building (VAB) designs for cable removal and VAB door modifications complete
- Crawler Transporter-2 moved into VAB HB-2 to continue modification
- VAB Door Project contract awarded to USA
- Pad B LH2/LO2 Cross Country Pedestal Refurbishment complete
- Tank Refurbishment sandblasting and painting started
- ML Structural Design Contract awarded to RS&H
- Received tilt-up umbilical arm test article at the Launch Equipment Test Facility (LETF)
- LETF Testing is scheduled to start beginning of May, 2012
- Initiated construction on CRF facility to support Orion Launch Abort System (LAS) assembly for EFT1
- Orion Ground Test Article (GTA) at KSC for GSE development









### **Overall Flight Test Strategy**

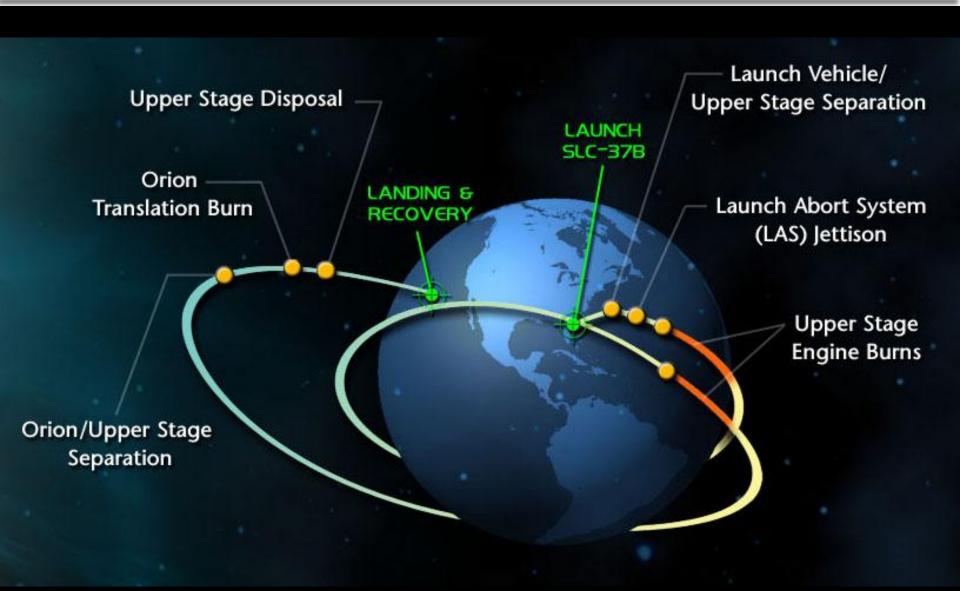
### Mission/Flight Test Objectives



- Flights are needed to test critical mission events and demonstrate performance in relevant environments
  - Abort, jettison, separation, chute deploy, Re-entry and TPS performance in BEO conditions, Integrated vehicle systems performance, and environments validation
  - Data collected from flights will be used to eliminate additional SLS test flights as the SLS configuration evolves
  - Dedicated flight tests will not be required for incorporation of competitive boosters, RS-25E, or the upper stage (with J-2X)
- Four missions/test flights planned to meet minimum mission/flight test
  - Exploration Flight Test-1 (EFT-1), an orbital, uncrewed test flight in 2014 provides MPVC system level tests and risk reduction opportunity
  - Ascent Abort-2 (AA-2), an abort test in high dynamic pressure environment
  - Exploration Mission-1 (EM-1), an Un-crewed BEO (lunar flyby) and EM-2, a crewed BEO flight (includes 3-4 day lunar orbit) will provide more system level testing and shakedown

### **Exploration Flight Test 1**



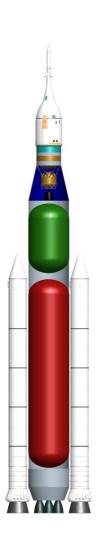


# Exploration Mission – 1 (EM-1) BEO Un-crewed Flight



- Mission description
  - Un-crewed circumlunar flight free return trajectory
  - Mission duration ~7 days
- Mission objectives
  - Demonstrate integrated spacecraft systems performance prior to crewed flight
  - Demonstrate high speed entry (~11 km/s) and TPS prior to crewed flight
- Spacecraft configuration
  - Orion "Block 0 Lunar"
- Launch vehicle configuration
  - SLS Block 0, 5 segment SRBs, 3 SSMEs, 70-80 t
  - Interim Cryogenic Propulsion Stage (ICPS)
- Launch site
  - KSC LC-39B



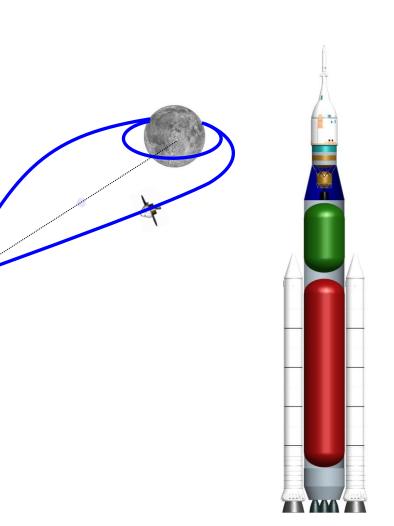


## Exploration Mission – 2 (EM-2) BEO Crewed Flight



- Mission description
  - Crewed lunar orbit mission
  - Mission duration 10-14 days
- Mission objectives
  - Demonstrate crewed flight beyond LEO
- Spacecraft configuration
  - Orion "Block 0 Lunar"
- Launch vehicle configuration
  - SLS Block 0, 5 segment SRBs, 3 SSMEs, 70-80 t
  - Interim Cryogenic Propulsion Stage (ICPS)
- Launch site
  - KSC LC-39B







### **Affordability**

### Improving the Affordability of Spaceflight Programs



### Accelerate Decision-Making

Flatten Organization -Clear Authority & Accountability

Push Reserves to Programs

Reduce Frequency of Agency-level Reviews

Identify Best Practices & Implement Lessons Learned

Streamline Certificate of Flight Readiness Process

### Manage Program RQ & Contractor Interfaces

Streamline and Stabilize Requirements

Eliminate Non-Value Added NASA & FAR RQ

Define Strategy & Clear Roles for Oversight/Insight

Develop Mitigation Plans for High Risks / Cost Drivers

Adopt Appropriate
Safety & Risk Posture

Leverage Use of In-House Capability

### Maintain Competition & Improve Acquisitions

Focus on Key Driving Requirements

Maximize Use of Industry Standards

Implement "Should Cost"
Based Management

Incentivize Contractors for Effective Cost Mgmt

Maximize Competition thru the Life of Program

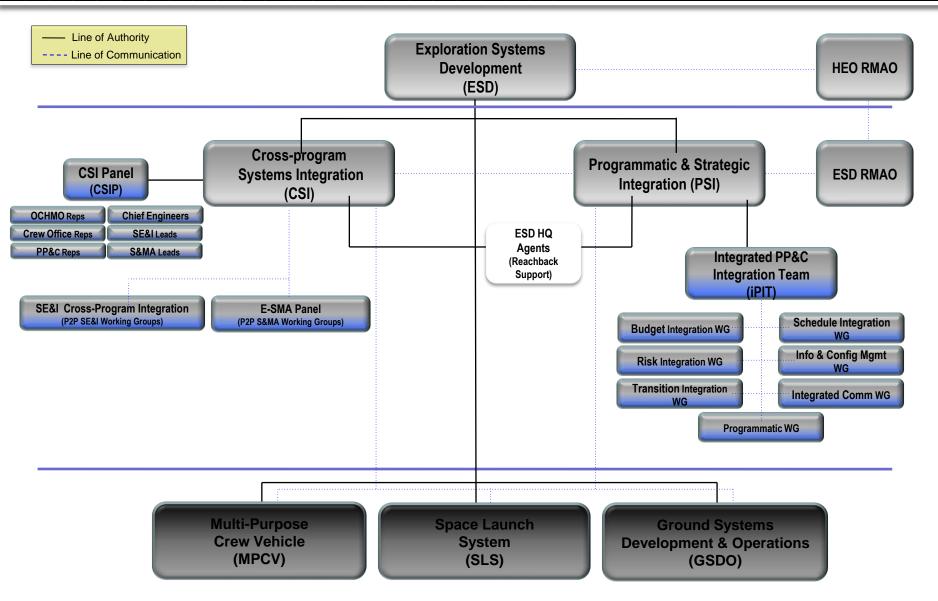
Capitalize on Progress
Payment Structures

## ESD Actions - Accelerate Decision-Making Velocity



- Leveraging Lessons Learned from Prior Development Programs
  - Apollo Program
  - Shuttle Program
  - ISS Program
  - Constellation Program
  - Ares 1X Flight Demonstration Project
  - Standing Review Board
  - Booz Allen Hamilton
  - Industry Input on Affordability 1-on-1 meetings and SLS BAA input
  - DoD Better Buying Power Initiatives
  - NASA/DAU Program Executability Workshop
- Overhauled the Governance Structure: (See next slide.)
  - Flattened organization removed a layer
  - Clear delegation of authority and accountability
  - Tri-program integration and increased authority at lower level decision-boards
  - Pushed reserves to the programs consistent with authority & accountability and to improve decision-making velocity
  - · Instituted fewer meetings and streamlined reporting
- Implementing a New, Efficient, Distributed Integration Approach
  - ESD leads with reach back to the Programs & Centers through -
    - ESD Office of Cross Program Systems Integration (CSI)
    - ESD Office of Programmatic & Strategic Integration (PSI)

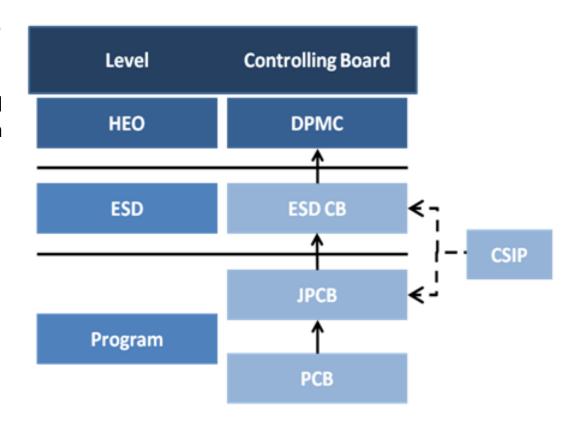
## Organization and Interfaces ESD Division and Program-to-Program Working Groups (WGs)



## ESD's integration model creates two primary levels for integration with direct program access to ESD boards



- The ESD integration model has two pathways for decisions.
- Decisions can (and are encouraged to) be made at the level below each Program Control Board (PCB), i.e. at each Chief Engineer's (CE) Board.
- Reps from ESD and the other programs are at those CE boards so information and issues are shared.
- If a decision isn't agreed on at a lower level, it can be raised to the ESD CB or at the Joint PCB (JPCB), depending on whether the agreement is relating to an integration issue or a general shared program issue.



### **ESD - Efficient Integration Leads to Affordability**



Integration during Constellation and ESD					
	Budget (M\$)	FTE	WYE		
Constellation Integration Project Office	133	359	431		
ESD	16	74.5	41.95		

#### Notes on Comparison:

- Budget is procurement and travel-only
- CxP was at PDR when these values were taken; ESD is still in formulation, so an *exact* comparison is not yet appropriate. Many of the tasks that CxP Integration performed are now shared between ESD and the programs.
- CxP Integration is estimated to have been 359 FTEs from the 2007 SRR thru 2009.
- ESD estimate includes Center-based FTEs but does not include FTEs charging to Programs who do part-time work focused on integration.
  - ESD has 26 FTE at HQ, 48.5 FTE at the centers.

Under the leadership and guidance of ESD, integration efforts and decision-making formally occur at lower levels and are more affordable than in the CxP.

## **ESD Actions - Streamline Requirements, Define Government Roles and Manage Risk Posture**

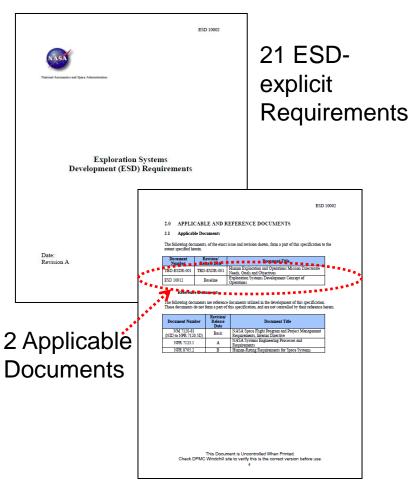


- Including affordability as a key element of requirements (Slides to follow.)
  - Assessing the impact of each requirement on affordability
  - Encouraging commonality and utilization of industry standards versus NASA unique requirements.
  - Streamlining and minimizing key driving requirements
    - ESD issued only <u>21 level one requirements</u>; CxP had several hundred.
  - Striving to maintain stability of requirements
- Strategically focused staffing approach for insight / oversight of contractor performance
  - Minimizing number of Gov't staff performing insight/oversight
  - Following a risk-based or a hybrid approach
  - Focusing, limiting and clarifying Government roles pertaining to interactions with and direction to contractor.
- Balanced approach to managing risk
  - Mitigating key risks based on available budget; risk acceptance will be documented and approved through Agency processes.
  - Connecting risk approach to use of reserves will allow ESD to strategically choose the most important risks to mitigate.

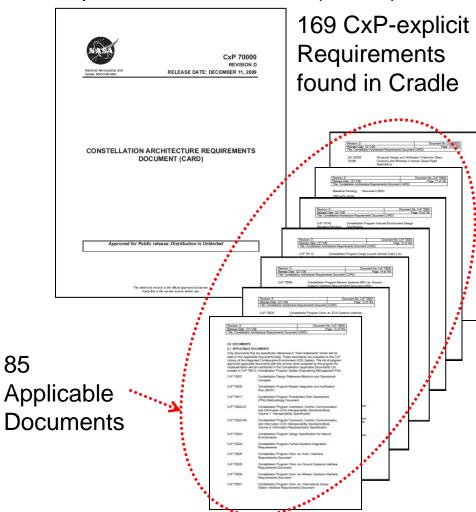
## Exponential Impact of Streamlining Requirements: An Example (1 of 3)



### ESD 10002, Exploration Systems Development Requirements

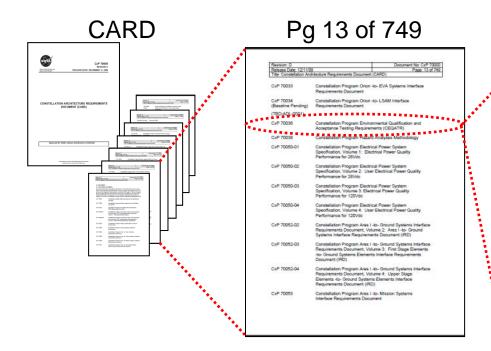


### CxP 70000, Constellation Architectural Requirements Document (CARD)



## **Exponential Impact of Requirements: Citing Standards in Requirements Documents (2 of 3)**

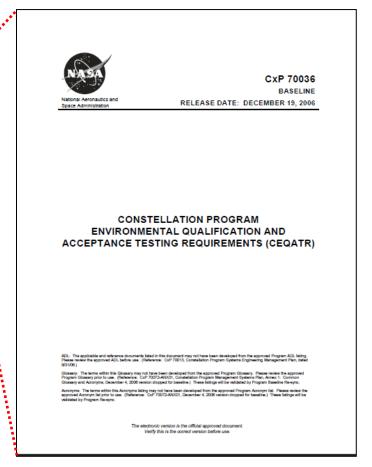




What was the impact of this **one** document?

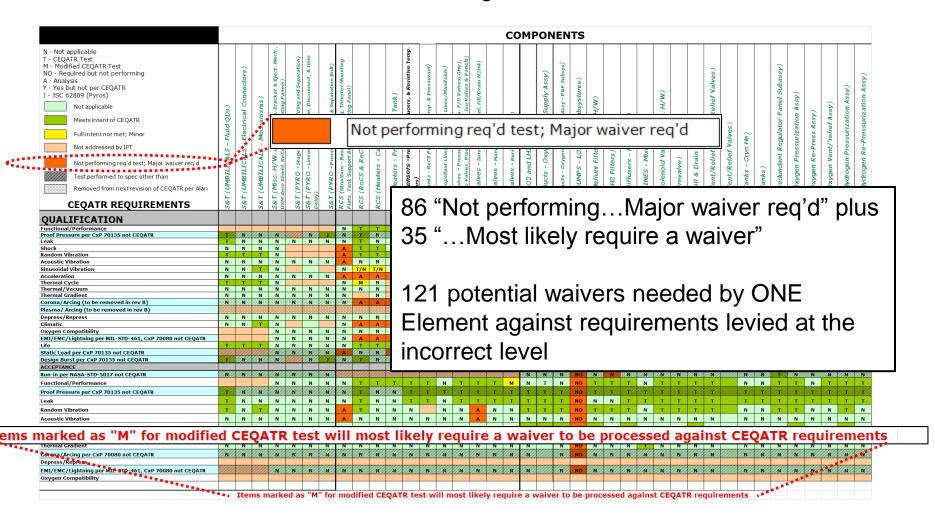
660 individual "shall" statements spanning 120 pages...

### 1 Document from 85 Applicable—the CEQATR



## Exponential Impact of Requirements: Example of Assessment & Compliance Necessary (3 of 3)

#### A "Meets or Exceeds" assessment against the baseline CEQATR:



# ESD Actions - Maintain Competition and Improve Acquisitions



- Conducting 'Will Cost' and 'Should Cost' Reviews
  - Conducted a 'Should Cost' training session
  - Booz Allen support of Independent Cost Assessment
  - DoD Price Fighters assisting SLS Integrated Assessment Teams
  - DCMA to assist with 'Should Cost' review of Contractor overhead
- Implementing Contract Incentives for Cost Reductions
  - Maximizing use of cost plus incentive fee and fixed-price incentive fee type contracts
- Issuing Multiple Lower-Level Contracts vs Large System Level
  - Reduces pass through of subcontracting overhead & fees
  - Enables greater insight and ability to define requirements
  - Enable direct employment of contractor performance incentives
  - Improves competition
    - SLS: Element-level contracts
    - Ground Dev & Ops: Fixed Price IDIQ contracts
- Leveraging Existing Assets
  - Evolving launch capability
  - Enabling early demonstration of capabilities
  - Helping to mitigate risks

### Affordability: Implementation by the ESD Programs 🙌

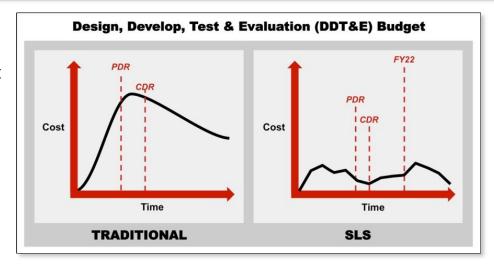


- Space Launch System (SLS)
- Orion/Multi-Purpose Crew Vehicle (Orion)
- Ground Systems Development & Operations (GSDO)

## SLS Program Implementation Approach – Affordability Begins with Accountability (1 of 2)



- Evolvable Development Approach
  - Manage requirements within constrained, flat budgets
  - Leverage existing National capabilities
    - Liquid oxygen/hydrogen propulsion infrastructure
    - Manufacturing and launch-site facilities
  - Infuse new design solutions for affordability
- · Robust Designs and Margins
  - Performance traded for cost and schedule
  - Heritage hardware and manufacturing solutions
  - Adequate management reserves controlled at lower levels
- Risk-Informed Government Insight/Oversight Model
  - Insight based on:
    - Historic failures
    - Industry partner past performance and gaps
    - Complexity and design challenges
  - Judicious oversight:
    - Discrete oversight vs. near continuous
    - Timely and effective decisions



#### Right-Sized Documentation and Standards

- 80% Reduction in the number of Type 1 Data
   Requirement Documents from the Ares Projects
- Increased use of industry practices and tailored NASA standards
- Lean, Integrated Teams with Accelerated Decision Making
  - Simple, clear technical interfaces with contractors
  - Integrated Systems Engineering & Integration organization
  - Empowered decision makers at all levels
  - Fewer control Boards and streamlined change process

# SLS Program - Initial Results in Minimizing Standards (2 of 2)



- There are three types of requirements documents:
  - 1. Type 1 documents are those that contain requirements that must be met as written;
  - 2. Type 2 documents are those that contain requirements that the contractor can either choose to adopt, or propose an alternate; and
  - 3. Type 3 documents are those that contain requirements where the contractor does not need to either formally adopt the document.
- For SLS, approach was that no technical specifications or standards be declared type I.
   Type 2 documents and requirements can ensure quality and can alternatively be met by proven industry standards (approach proposed from BAAs).
- · Recent evaluation of found there are currently:

-	SLS Type 1:	0	vs in CxP, Ares had ~ 773 Type 1
_	SLS Type z:	44	
_	SLS Type 2 S&MA:	15	
_	SLS Type 3:	53	
_	SLS Extended Total:	820	

SLS has reduced the requirements burden it will impose on contractors which greatly improves affordability.

# Orion Program Implementation Approach - Affordability



- Orion affordability initiatives in 2010-2011 have reduced DDT&E cost and enabled schedule acceleration.
- Initiatives include:
  - Incremental approach to building and testing vehicle capabilities
  - Streamlined government oversight and insight that focuses on key-risk items and collocation with Prime contractor in selected areas
    - Procurement \$ for oversight reduced nearly 70%, FTE working on oversight reduced 40-45% (not including add backs for MOD and suits)
    - Inline tasks were added to remaining insight/oversight resources realizing the benefits of 'hybrid model' engagement
    - Insight reported to be good due to improved team relationships and inline involvement
  - Reduced formal deliverables and simplified processes while retaining adequate rigor
  - Partnering with suppliers to analyze cost drivers and possible efficiencies
  - Consolidating test labs and re-using test articles

Orion's incremental development approach and right-sizing of insight/oversight staffing make it affordable within a smaller budget.

# Ground Systems Development and Operations Program – Approach to Affordability (1 of 2)



- Leveraging the use of existing Shuttle/ISS and Constellation assets where practical
  - Rely on utilization of heritage systems and assets with respect to probability of mission success within applicable standards.
    - LC39 Pad B (clean pad)
    - Uses modified Ares 1-ML
    - Integration: VAB High Bay-3
    - Utilizes CxP Crew/Crew Module Recovery Approach
- Infusing operability into designs of flight and ground systems
- Synergizing between Exploration Ground Systems and 21CSLC
  - Promoting multi-use Commercial and Government
  - Sharing use of SLS/Orion capabilities (VAB, LC-39B, Crawlers, etc.)
- Reducing infrastructure footprint and operating costs by:
  - Utilizing a single string architecture to provide a significant reduction from previous HEO programs
  - Working with KSC institution to reduce footprint
    - Soliciting industry and other government interest in unfunded capabilities (OPF, NASA Depot, etc.)
    - Demolishing facilities with no identified needs.



## Ground Systems Development and Operations Program – Approach to Affordability (2 of 2)



- Civil Servants perform the traditional "Prime" role for management & integration
  - Allows Ground Operations to quickly respond to changing program direction with minimal cost/schedule impact
  - Avoids overhead costs on subcontracts, and is different from the Shuttle-USA experience
- Acquisition approach enables flexibility and maximizes competition.
  - Reduce schedule and procurement costs through 'best value' fixed-price IDIQ contracts. Pre-qualify and pre-stage supplier pools (designers, fabricators, constructors):
    - Design IDIQ contracts (in place)
    - Construction IDIQ contracts (in place)
    - GSE Fabrication IDIQ contracts (in place)
    - Craft Labor contract for installation support (in planning)

### ESD - A Fresh Start to Improve Affordability...



- Major cost drivers in human space flight are organizational structures, requirements and acquisition strategy / contract management.
- ESD and its programs are different compared to recent NASA experiences, but similar to the Apollo approach.
- This new beginning through ESD is enabling NASA to pursue a more efficient and affordable future to human space flight by implementing approaches to secure better buying power, such as:
  - Accelerating Decision-Making
  - Better Managing Program Requirements & Contractor Interfaces, and
  - Improving Acquisition Strategy and Implementation



### Questions?

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